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Evaporation Memorandum No. 44

Provisional maps of Potential Soil Moisture Deficit

B G Wales-Smith

1. Introduction

To meet a request from the editors of the Atlas of Drought sponsored by the Institution of British Geographers, maps have been produced to show the average end-of-month potential soil moisture deficit over the period 1956 to 1975 for the months of April to August, and the situation in those same months in the the drought year of 1976.

2. Potential Soil Moisture Deficit

If from some date when the soil is at 'field capacity', the quantity Potential Evaporation minus Rainfall is calculated (preferably on a daily basis) the accumulated +ve difference at the end of a nominated period is known as the Potential Soil Moisture Deficit.

Numerical values of potential soil moisture deficit do not have an arbitrary upper bound since the assumption is made that soil moisture is always freely available. Farm crops should avoid the charges on production imposed by soil moisture stress and for this reason, potential soil moisture deficit is a useful guide to total irrigation need (after due allowance is made for the soil moisture resources that are readily available to plants).

By convention, potential soil moisture deficit is returned to zero when the actual soil moisture deficit appropriate to a root constant of 76 mm (3 inches) (Penman 1949) returns to zero. This procedure normally prevents large and irrelevant values of potential soil moisture deficit being carried over from one growing season to the next. If the actual soil moisture deficit of the model of crop water usuage that employs a 76 mm (3 inch) root constant does not return to zero during the winter, the end of February potential soil moisture deficit is set to the value of the actual deficit of the 76 mm root constant model at the end of February.

3. Data and Processing: 1976 Maps

Estimates of end-of-month potential soil moisture deficit for some 200 places in Great Britain are produced routinely by the Meteorological Office as a by-product of the Soil Moisture Deficit Bulletin Service (Grindley 1967).

The evaporation data used are montly approximations to Penman (1948) potential evaporation following Smith (1967) and are apportioned to individual days by reference to a seasonal curve; rainfall data are measured daily values. In the winter period, from October to March, potential evaporation is not calculated but is assumed to take the low climatological average values of that time of the year.

The data leading to the maps for 1976 were as extensive as time allowed. The 200, end-of-month potential soil moisture deficit place values for the spring, and summer of 1976 (April to August inclusive) were supplemented by the information implicit in the maps issued at fortnightly intervals showing isopleths of actual soil moisture deficit (derived from the 76 mm root constant model) and tables relating actual and potential soil moisture deficit (Grindley 1969).

Simple isopleth analysis was carried out to derive Figures 1a to 1e. Particular attention was paid to continuity and topography in data-sparse areas.

4. Data-processing 2: 1956-75 average maps

Monthly averages of Penman (1948) potential evaporation, (with a minor modification described by Grindley, 1970), are calculated, routinely, by the Meteorological Office, for some 72 stations in Great Britain. Average values have been worked for the period 1956-1975. Monthly rainfall averages, for the same stations, are available for the most recent standard period 1941-70. The assumption has been made that the 1941-70 rainfall averages may be used as approximations to those of the period 1956-1975. Wales-Smith (1977a) has shown that a good approximation to end-of-August potential soil moisture deficit can be obtained by assuming field capacity at the end of March and calculating potential soil mositure deficit on a monthly basis thereafter. No end-of-month potential soil moisture deficit value is allowed to take a negative value.

Using the above method, average end-of-month potential soil moisture deficit values were calculated for the 72 stations. The values were plotted on maps (Figures 2a to 2e) and simple isopleth patterns were drawn as for the year 1976).

5. Quality of the analyses

The 1976 maps are based on a large quantity of data but the potential evaporation input is an approximation to that given by Penman's formula. The approximation is quite good, as shown by Wales-Smith and Mackenzie (1976) but is biased towards average conditions.

The 1956-75 average maps are based on Penman (1948) potential evaporation (with a minor modification) but use monthly rather than daily rainfall totals. As already pointed out, the potential evaporation and rainfall averages are for disparate but overlapping (15 year) periods. The assumption that the soil moisture deficit is zero at the end-of-March is generally true, but it is not an invariable rule for all seasons and locations. The number of data points used is not large and the analyses must be regarded as presenting the broad picture rather than a set of reliable point values for all parts of Great Britain.

6. Summary and Conclusions

Maps of end-of-month potential soil moisture deficit have been produced for the drought year of 1976 together with long period average values (1956-1975) for comparison. The limitations of the data and the methods adopted, are acknowledged. Incorporation of all available data, an improved potential evaporation estimate and uniform calculation procedure would be expected to change the detail but not the degree and extent of the departure of 1976 from the long period normal.

The data show that the departure of the 1976 end-of-season potential soil moisture deficit from average was not solely attributable to the deficit carried over from the previous season and that an additional and highly significant evaporative demand built up in the 1976 season itself.

Using independent data, Wales-Smith (1977b) has suggested that the periods April to July and April to August 1976 at Kew, Surrey had the highest totals of potential evaporation for those months since 1876 and very probably since 1698.

February 1978

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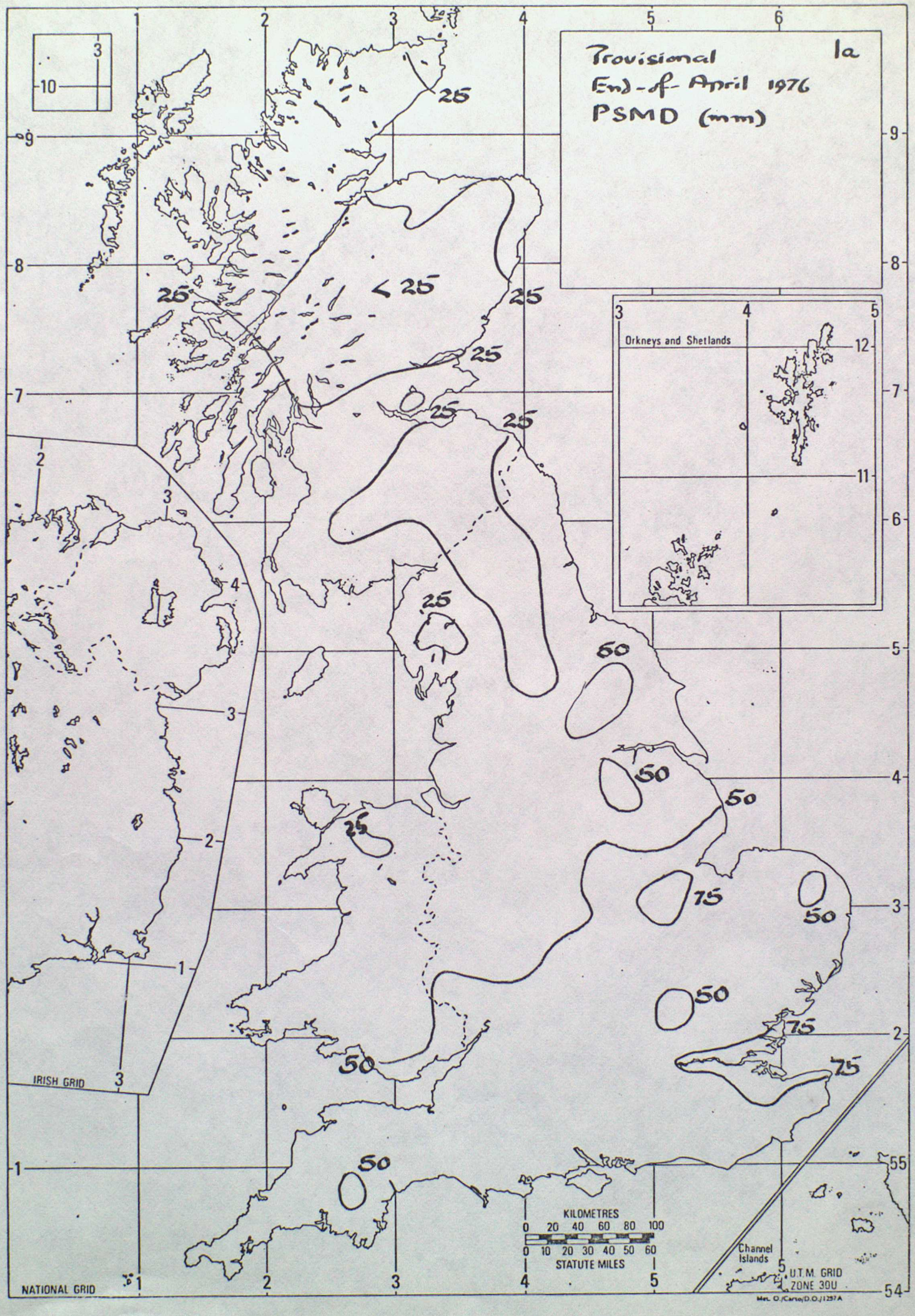
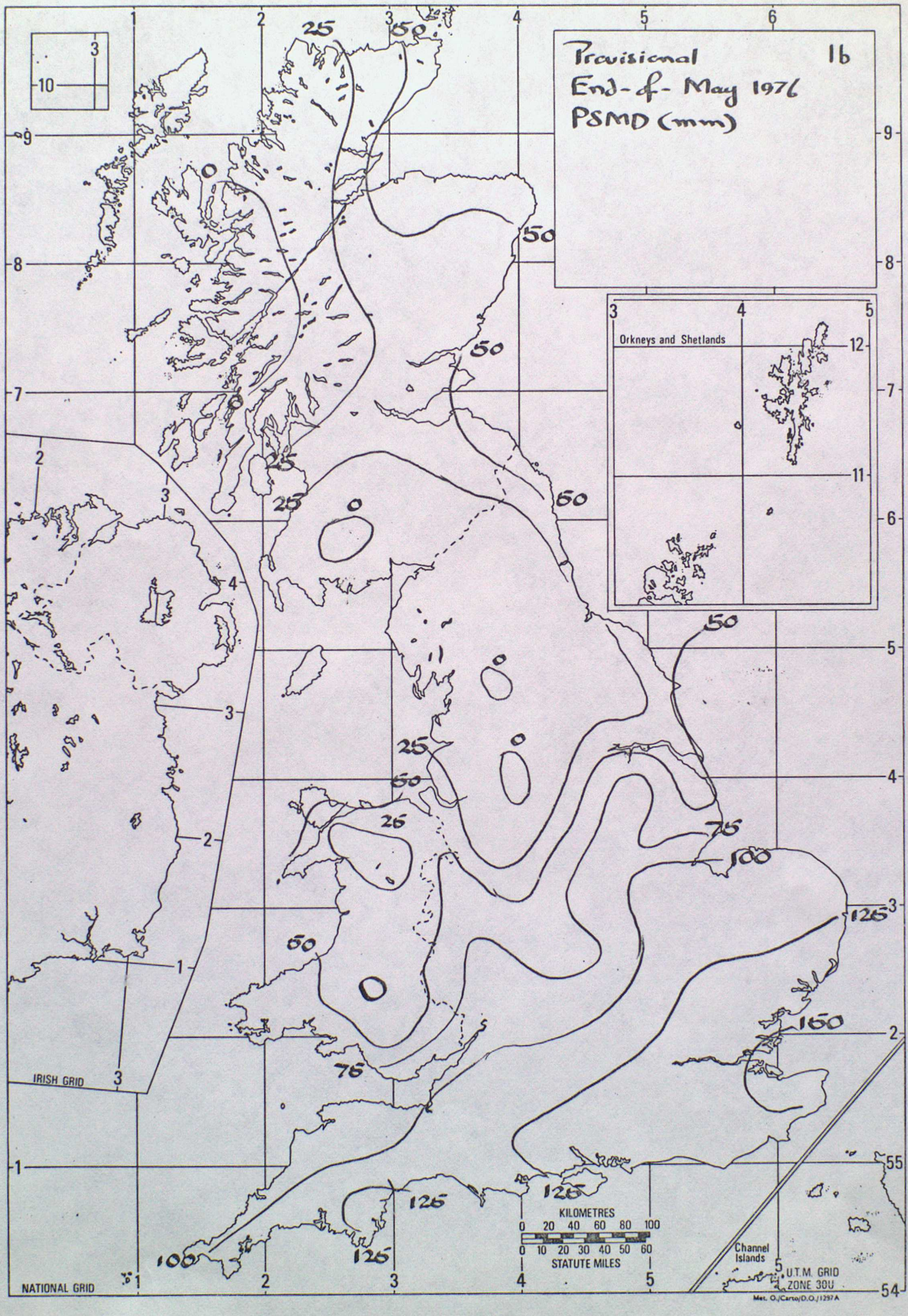
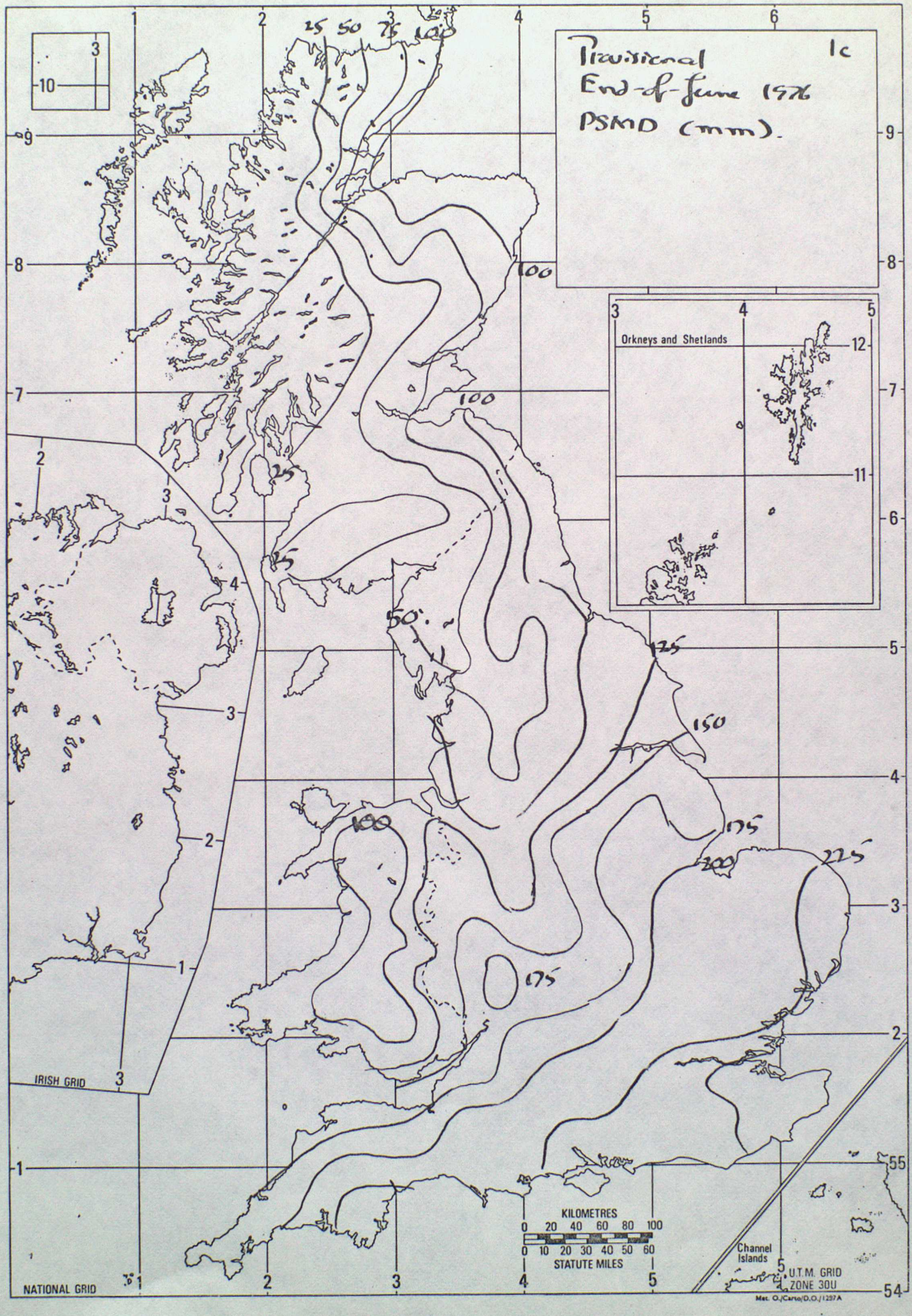
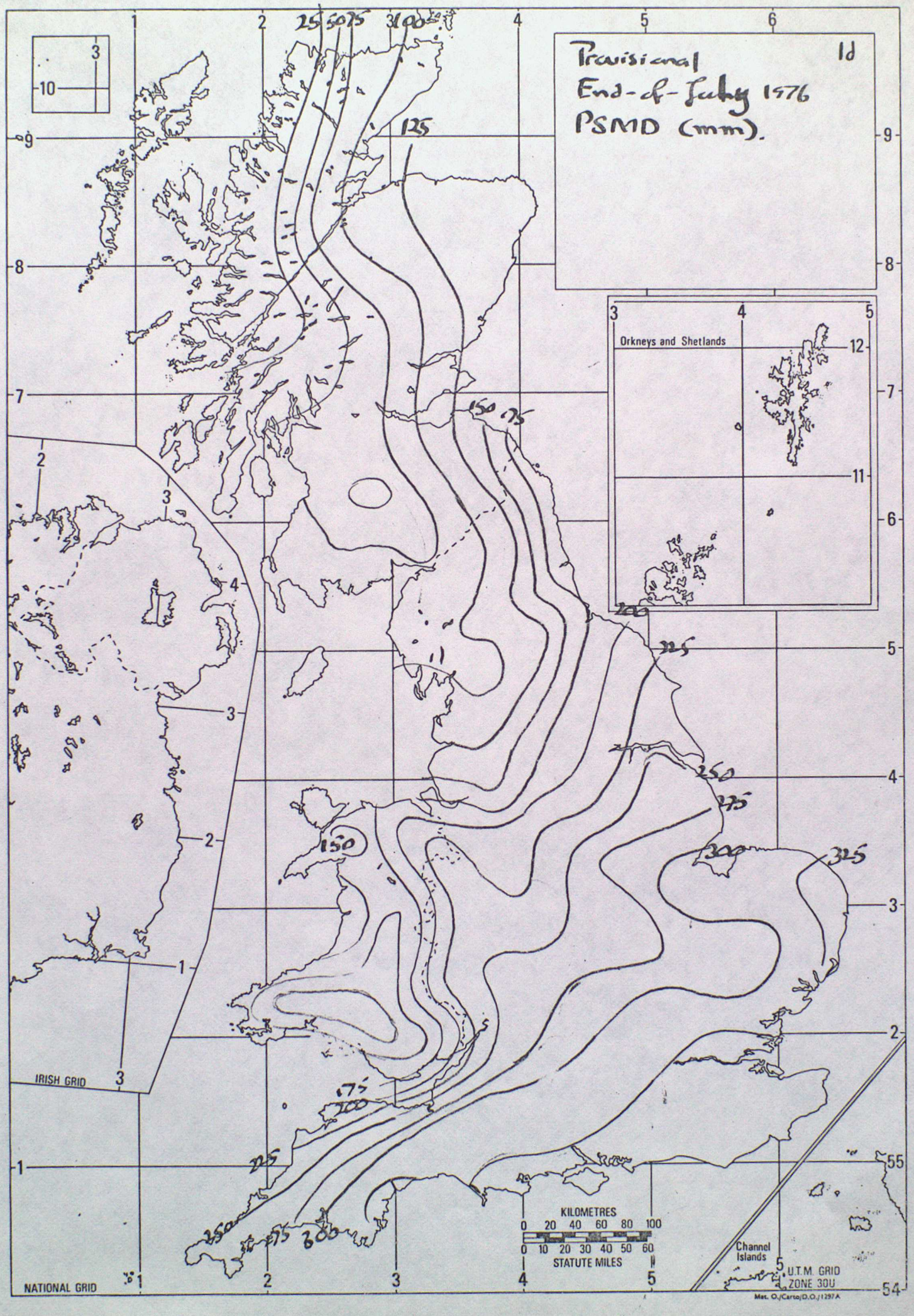

Provisional
End-of-April 1976
PSMD (mm)
1a
Orkneys and Shetlands
< 25
25
50
75
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U


Provisional
End-of-May 1976
PSMD (mm)
1b
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID ZONE 30U
Met. O./Carto/D.O./1297A


Provisional
End-of-June 1976
PSMD (mm).
1c
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U
Met. O./Carto/D.O./1297A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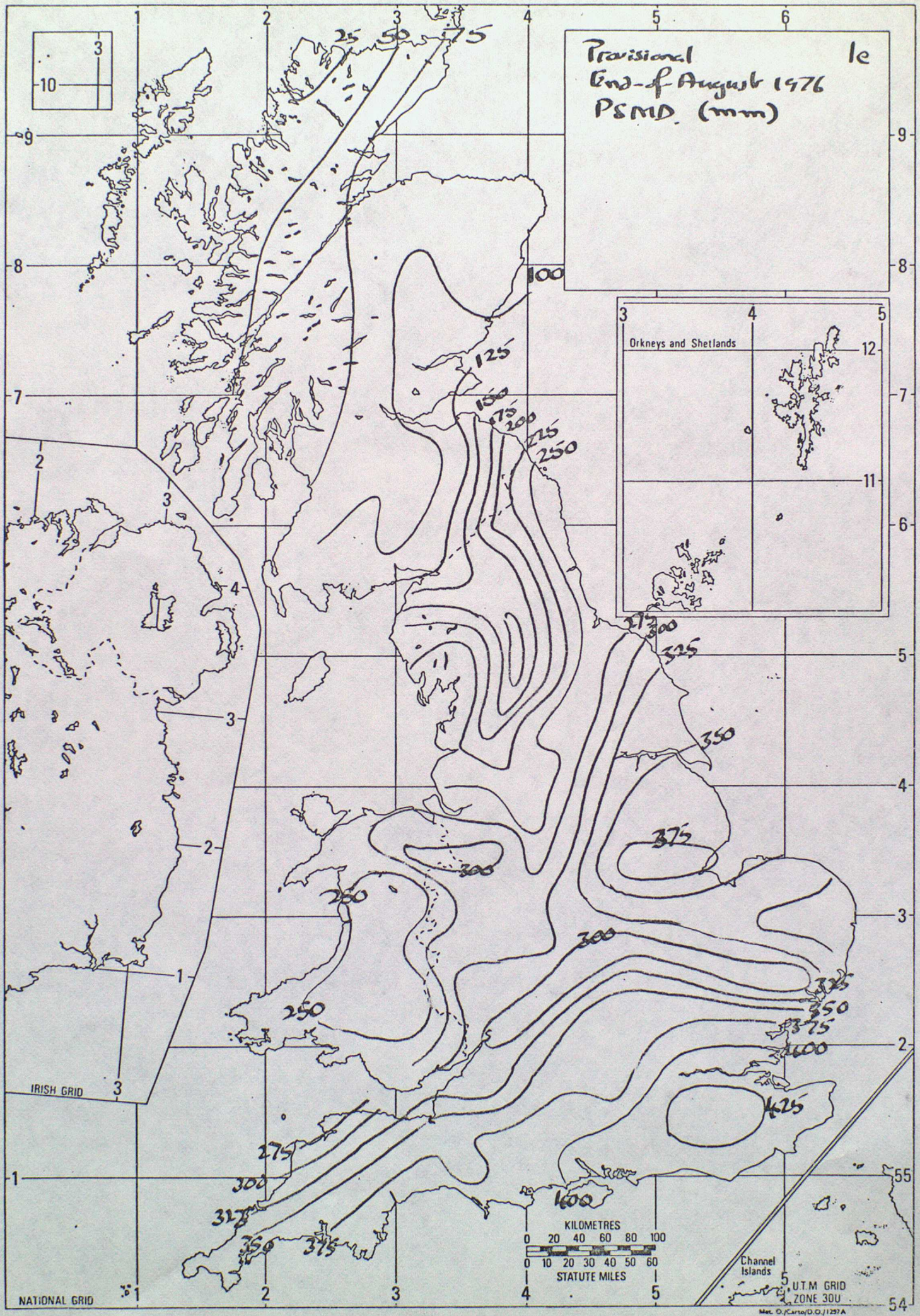
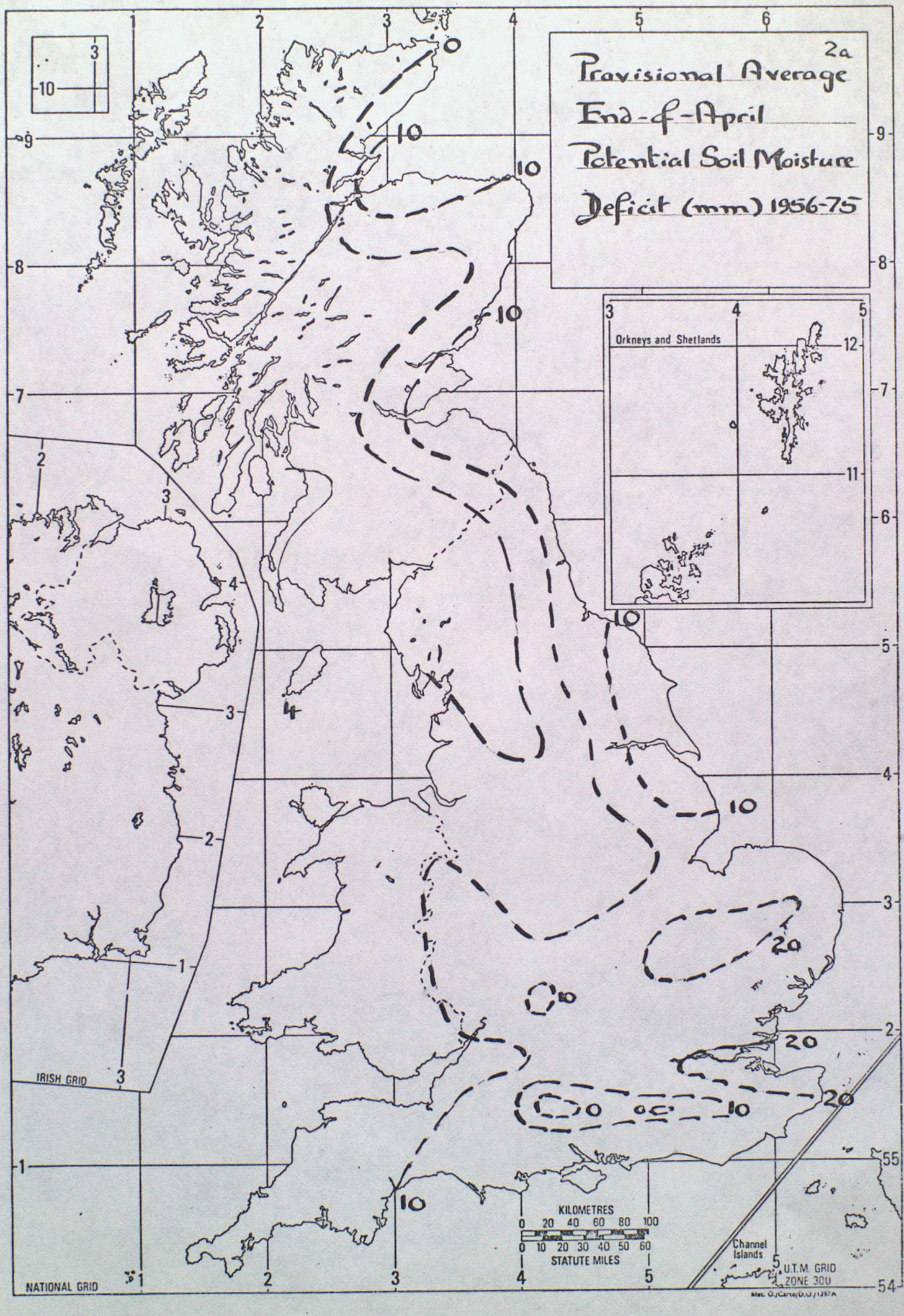
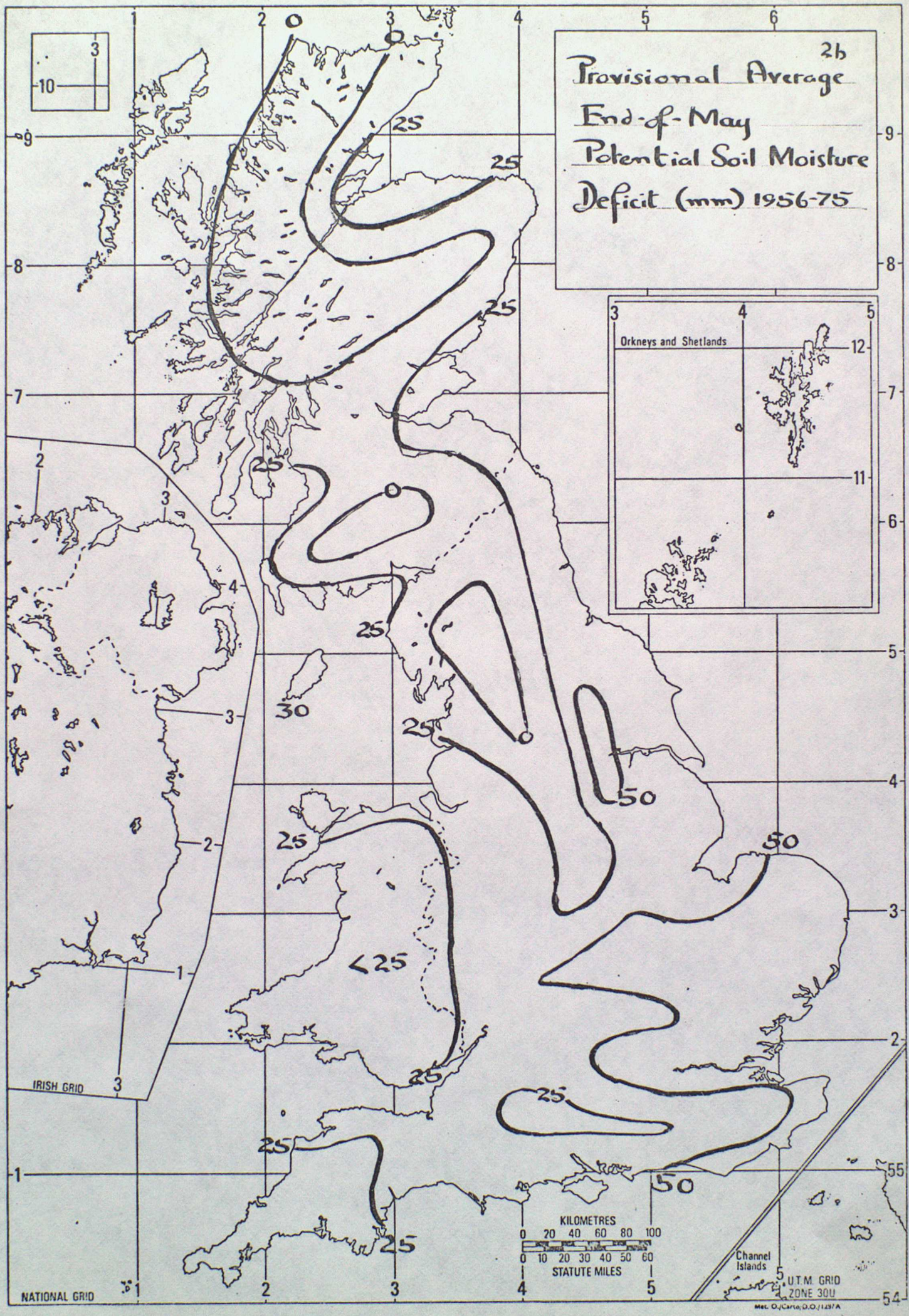
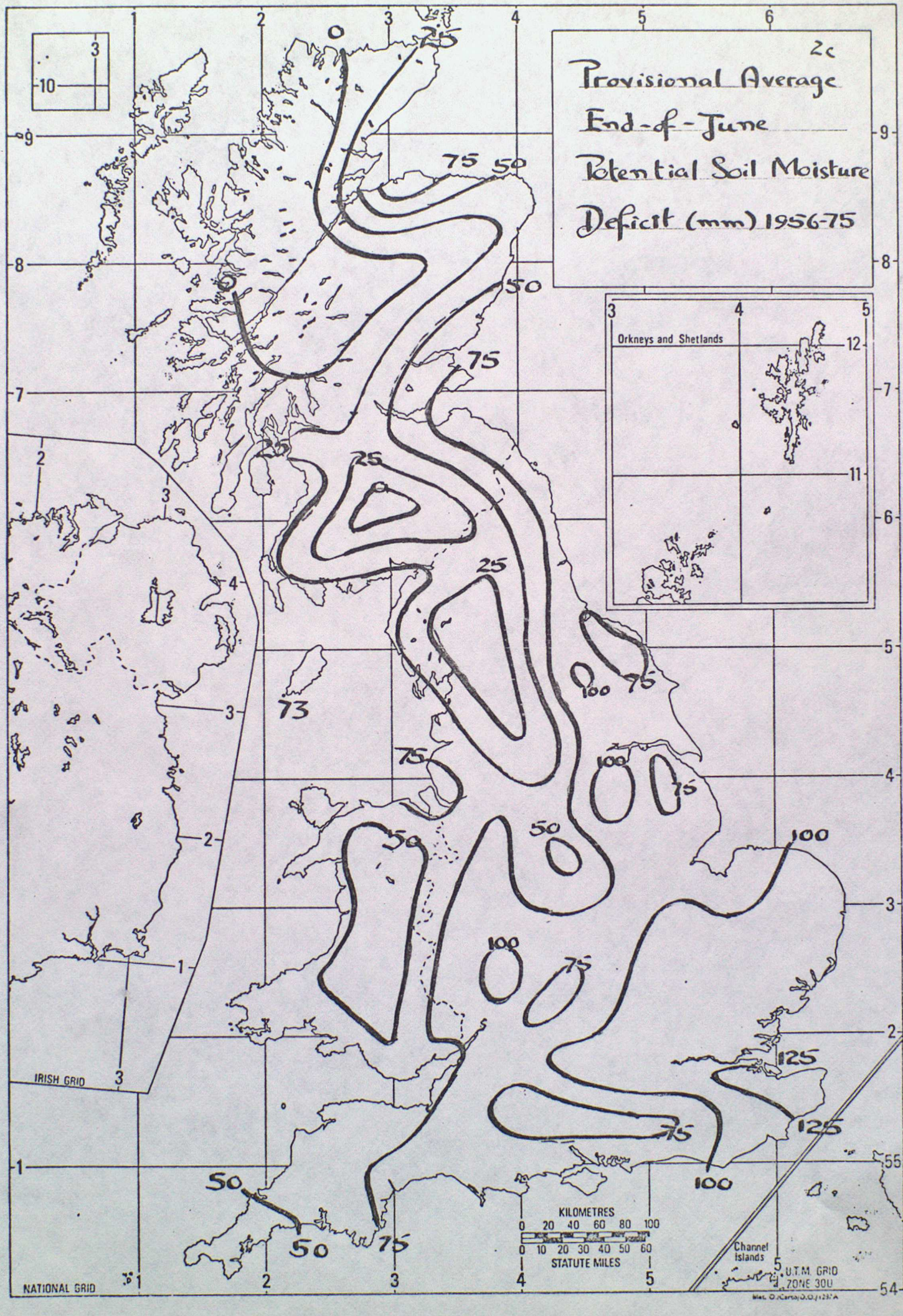
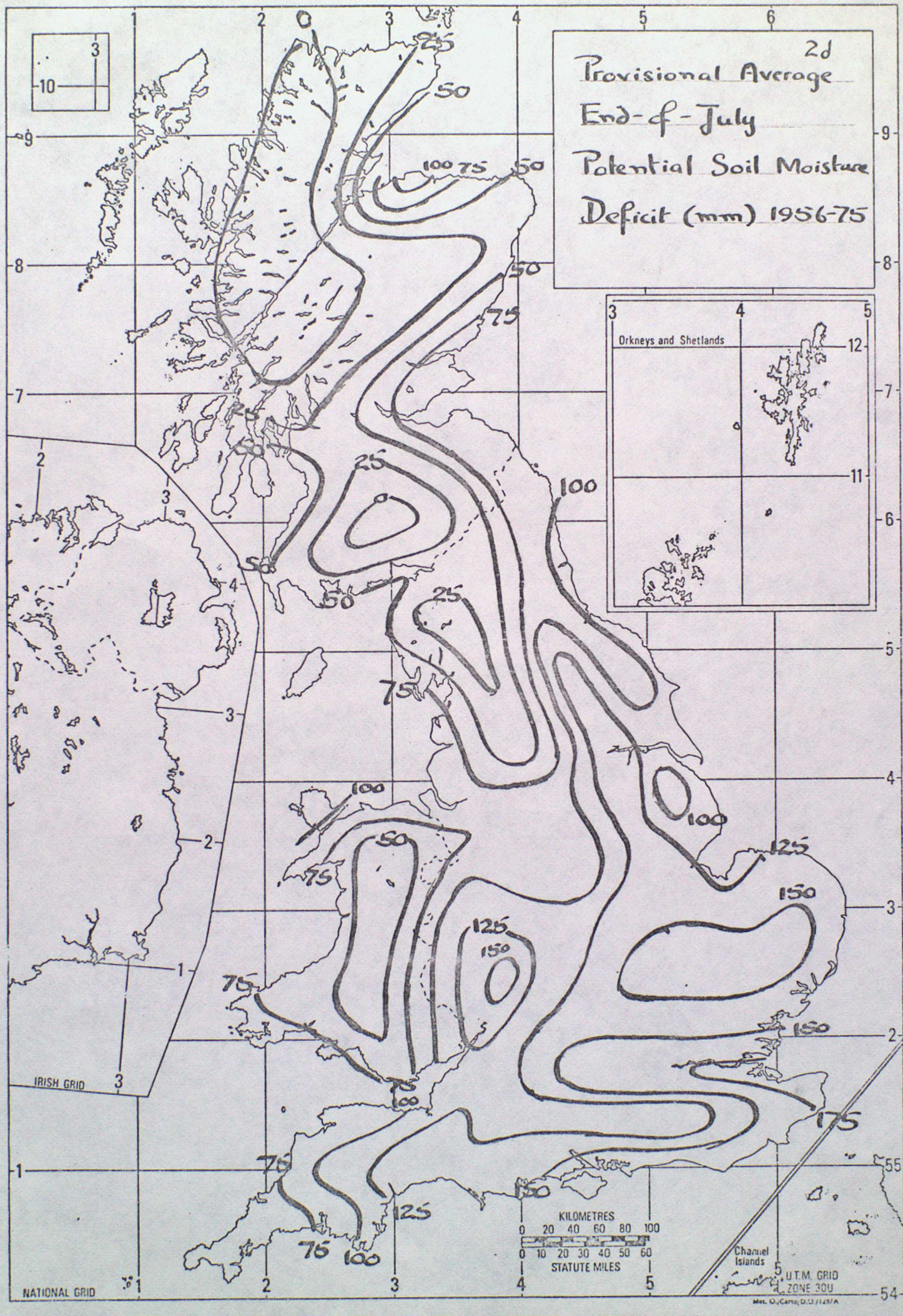
End-of-July 1976
PSMD (mm).
1d
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U
Met. O./Carto/D.O./1297A

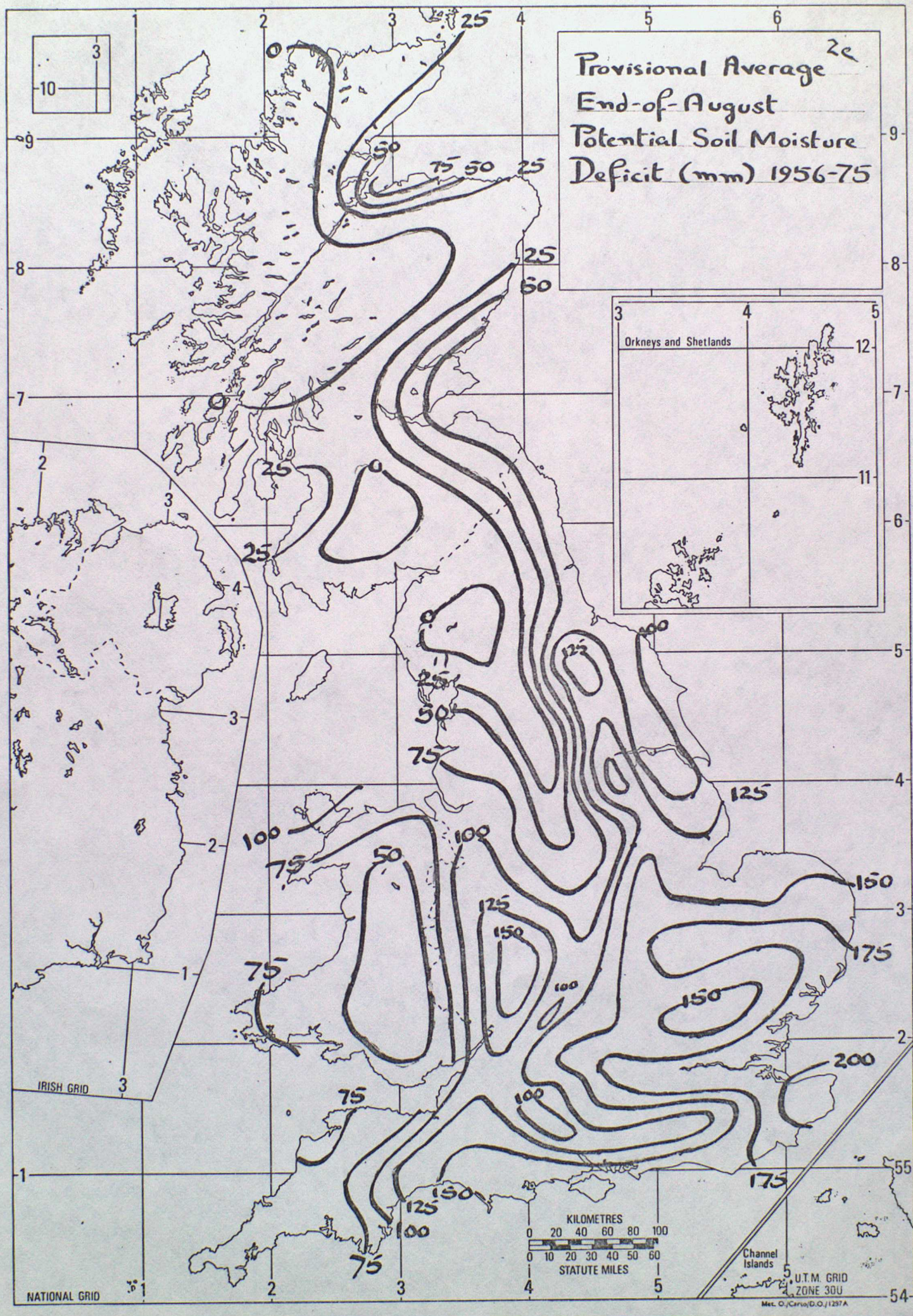

Provisional
End-of-August 1976
PSMD (mm)
1e
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M GRID ZONE 30U
Met. O./Carto/D.O./1257A


2a
Provisional Average
End-of-April
Potential Soil Moisture
Deficit (mm) 1956-75
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U


2b
Provisional Average
End-of-May
Potential Soil Moisture
Deficit (mm) 1956-75
Orkneys and Shetlands
0
25
30
50
<25
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U
Met. O.(Carto.)D.O./1237/A


2c
Provisional Average End-of-June Potential Soil Moisture Deficit (mm) 1956-75
Orkneys and Shetlands
0
25
50
75
100
125
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID ZONE 30U


2d
Provisional Average
End-of-July
Potential Soil Moisture
Deficit (mm) 1956-75
Orkneys and Shetlands
0
25
50
75
100
125
150
175
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID
ZONE 30U


Provisional Average End-of-August Potential Soil Moisture Deficit (mm) 1956-75
2c
Orkneys and Shetlands
IRISH GRID
NATIONAL GRID
KILOMETRES
0 20 40 60 80 100
0 10 20 30 40 50 60
STATUTE MILES
Channel Islands
U.T.M. GRID ZONE 30U
Met. O./Carto/D.O./1257A